A NEW APPROACH TO THE POTENTIAL ANALOGUE METHOD OF NETWORK SYNTHESIS

By

EDWARD WILLIAM SCHWARZ

B.S., University of Illinois, 1950
M.S., University of Illinois, 1951

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING
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The problem of electrical network synthesis is to determine a network with mathematical characteristics which approximate or equal preassigned mathematical characteristics.

Based on long experience with iterative and image parameters, and with insertion loss theory and measurement, it is found convenient to express some mathematical characteristics of electrical networks as a function $L(z)$ of the complex variable $z = x + i y$, where x and y are real variables, and where $e^{L(z)}$ represents the ratio of a steady state voltage or current to another steady state voltage or current of a lumped element network — sinusoidal operation, hence complex variable form. The ratio of any sinusoidal steady state voltage or current to any other sinusoidal steady state voltage or current (complex variable form) of a lumped element network is a rational function of the complex variable z.

If for synthesis purposes, a preassigned mathematical network characteristic is given as a function $F(z)$ of the complex variable z such that $e^{F(z)}$ is not a rational function, an approximation $L(z)$ to the preassigned mathematical characteristic $F(z)$ must be obtained such that $e^{L(z)}$ is a rational function — if a physical network is to be realized. In order that $e^{L(z)}$ be a rational function, the approximation $L(z)$ to the preassigned mathematical characteristic $F(z)$ must be a finite sum of logarithm terms, the coefficient of each logarithm term being an integer.

At the present time the potential analogue method of network synthesis is widely used as a method whereby a preassigned mathematical characteristic $F(z)$ can be approximated by a finite sum of logarithm terms $L(z)$. The potential analogue method is based on the observation that the complex potential of an array of infinitely long, uniformly charged line filaments is a finite sum of logarithm terms with integer coefficients. Thus the two mathematical forms, $L(z)$ for lumped networks and the complex potential for an array of line filaments, are the same. However, it is the opinion of the author that the analogue is more

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detrimental than useful. The implication of the potential analogue to those familiar with the method and particularly to those just entering the field is that all the vast amount of potential theory must be learned as a part of network synthesis. This thesis demonstrates that such is definitely not the case. Furthermore, it is demonstrated that the synthesis problem is better understood, more easily used, and more effectively developed and extended when free of the potential analogue encumberance. In short, it is shown that recognition of the rational form of $e^{L(z)}$ and the resulting simple mathematical form of $L(z)$ form a complete basis for the synthesis problem. The only other basic idea is the more or less obvious one that, if the preassigned function $e^{F(z)}$ is not rational, a rational approximation must be determined in order that a physical network exist which has mathematical characteristics approximating $e^{F(z)}$.

A method is developed whereby a given mathematical characteristic $F(z)$ can be approximated by a finite sum of logarithm terms. The approach used is general and is such that the coefficients of the logarithm terms are not restricted to be integers, but may be real valued or complex valued constants. As the approximation procedure is developed, the restrictions and assumptions are given that are necessary in order that an approximating finite sum of logarithm terms can be obtained when the approach as given in this thesis is used.

VITA

Edward William Schwarz was born on January 15, 1926, in Springfield, Illinois. After graduating from Lanphier High School in 1943, he worked at the Sangamo Electric Company in Springfield, Illinois until he entered the United States Navy in 1944 and served in the American and Pacific Theaters until his discharge in 1946. He entered the University of Illinois in 1946 and received the degree of Bachelor of Science, with high honors, from that institution in June 1950. In September 1950 he entered the Graduate College of the University of Illinois and received the degree of Master of Science in 1951. He held a Galvin Fellowship in the academic year 1950-51 and Radio Corporation of America Fellowships in the academic years 1951-52 and 1952-53. During the summers of 1946 through 1951 he was associated with the Sangamo Electric Company and was employed by the Bell Telephone Laboratories during the summer of 1952.